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Research Article

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Footwear intervene of forefoot loading during landing movement

Gu Y. D.[1], Lian W. L.[2] and Li Z. Y.[1]

[1]*School of Biological Science and Medical Engineering, Southeast University, Jiangsu, China*
[2]*Faculty of Sports Science, Ningbo University, Ningbo, China*

ABSTRACT

This study investigated the forefoot loading character under flexible sole condition while performing landing maneuver. Twenty healthy male volunteers have participated in the test. The insole and outsole loading were measured at the same time. The results of this study shown that the forefoot impact loading could be effectively relieved through the footwear during landing movement. The peak pressure value in the outsole was much higher than the barefoot, where the highest value in the first metatarsal of outsole was 63.6% higher than barefoot condition. Peak pressure of the third metatarsal of insole reduced the most, this has decreased about 51.2% of the barefoot experienced.

Keywords: landing; footwear; bare foot; plantar pressure; biomechanics

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INTRODUCTION

Landing is a common athletic maneuver which is always executed from different landing heights during intensive sports activities, such as badminton, volleyball, basketball and football [1]. Due to the presence of large ground impact and sudden deceleration, this action has been linked to lower extremity injuries, especially metatarsal fracture [2]. The shock experienced by the body caused by landing could be attenuated by several structures and mechanisms in the body including bone, cartilage, soft tissues etc. [3], but could also be attenuated through the footwear intervene. So many experimental studies, concerning the midsole influence, concluded that there is a strong correlation between the absorption of impact force and the shoe-sole stiffness [4]. However, some study has pointed out that the footwear wearing would affect foot natural motion. Specifically, running shoes were found to decrease from 6-220 to 0-60 the eversion/inversion amplitude relative to the natural barefoot torsion [5]. They concluded that the stiffer the shoe, the more natural motion of the foot was modified. In this study, we used the footwear, having a extremely flexible sole, to simulate barefoot, in this way to focus on the loading affect by the footwear without motion variety.

EXPERIMENTAL SECTION

Twenty male participants were recruited from physical education department. The age, mass, and height of the subjects were 22.6 (SD 2.3) years, 68.9 (SD 6.8) kg, and 1.78 (SD 0.06) m, respectively. All participants had feet within size range 41-43 fr in order to fit into the running shoes worn for the study. Participants were physically active and had no history of lower extremity injury in the previous 1 year leading up to the testing. All participants were noticed the intension of the test and signed a written informed consent in accordance with university regulations.

The outsole pressure data was measured through the Novel emed system (Novel GMBH, Munich, Germany), which is an automated, digitized pressure platform that analyzes pressure, force, and area data along the contact surface during static or dynamic movement. The resolution of this system is 0.25 sensors/cm2, and the sensor area of the platform measures 475mm×320 mm, with a total of 6080 sensors, and a pressure range of 10–1270 KPa. Meanwhile, a Pedar-X in-shoe pressure measurement system sampling at 50hz (Novel GMBH, Munich, Germany) was used to collect the in-sole plantar pressure data. Prior to the data collection session, the insoles were calibrated according to company

suggestions.

All subjects were asked to perform two-leg normal landing from plastic box with height of 30cm. Each subject was asked to complete six trials for bare foot and shoe wearing conditions. Nike free (running shoes) with very flexible sole which could reduce motion interfere, was chosen in this study.

RESULTS

During the forefoot landing process, the high pressure was appeared in the medial forefoot area under barefoot condition, but the outsole pressure distribution was highly related to the sole structure (Fig.1). Meanwhile, the general contact area was quite close, which means the shoes selected have good bending property.

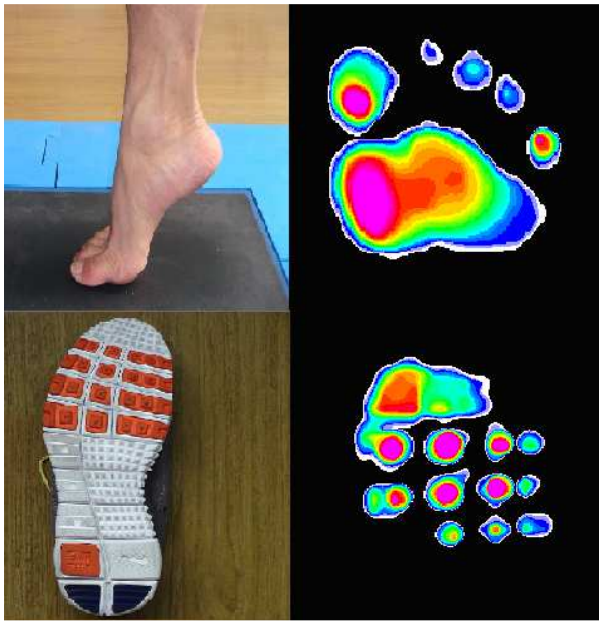
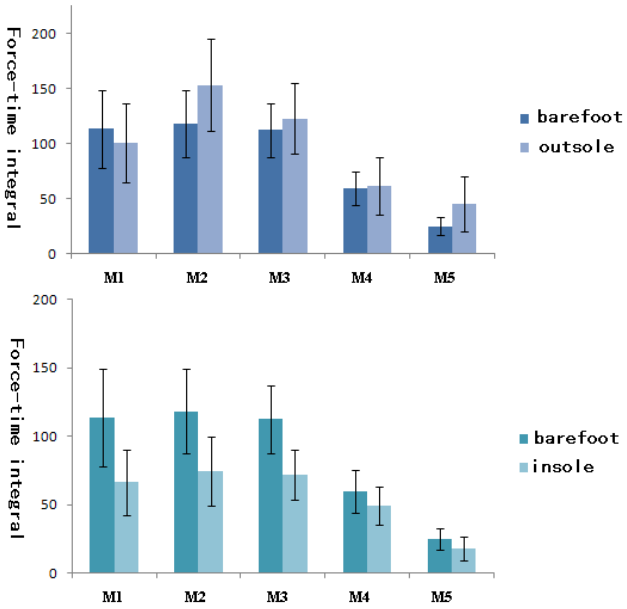


Figure 1. Plantar peak pressure distribution during the forefoot landing



Figrue 2 Force-time integral value in the five metatarsals region

Fig.2 shows the peak pressure value of barefoot and outsole during landing in the five metatarsals regions. The general pressure distributions were in the same sequence, in which the highest was in the first metatarsal, and the lowest was in the fifth metatarsal. However, the peak pressure value in the outsole was much higher than the barefoot, where the highest value in the first metatarsal of outsole was 63.6% higher than barefoot condition. But the peak pressure of five

metatarsals measured from insole shows the difference general distribution comparing to the barefoot condition. The biggest variety was in the middle metatarsals, which were quite close to the lateral metatarsals. Peak pressure of the third metatarsal of insole reduced the most, this has decreased about 51.2% of the barefoot experienced. While the fifth metatarsal of insole only reduced 15.9% of the barefoot experienced.

Fig.3 indicates the force-time integral value in the five metatarsals regions. Comparing this value in the barefoot to the outsole, only first metatarsal area present the barefoot larger than the outsole condition. But all these values in the insole were less than the barefoot condition. From the sole effectiveness point of view, the second metatarsal area has relieved the largest, in which nearly 51.5% reduced in insole comparing to the outsole condition.

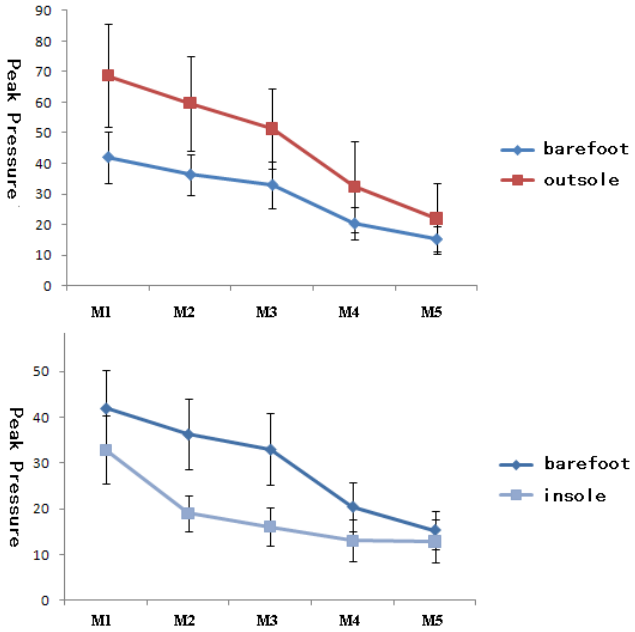


Figure 3 Peak pressure value in the five metatarsals region

DISCUSSION

The results of this study shows that the footwear could effectively reducing the forefoot impact loading during landing movement. Both peak pressure and force-time integral of plantar surface was largely reduced in the medial metatarsals area. This means the footwear's specifically protect design could be developed in this zone. Although we selected flexible sole to reduce the footwear intervene of natural motion, the kinematic data of forefoot in footwear condition during landing need further investigating.

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